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KOMMISSIONEN FOR HAVUNDERSØGELSER

SERIE: PLANKTON · BIND I

Nr. 13. Ove Paulsen: PLANKTON AND OTHER BIOLOGICAL INVESTIGATIONS IN THE SEA AROUND THE FÆROES IN 1913

KØBENHAVN
I KOMMISSION HOS C. A. REITZEL
BIANCO LUNOS BOGTRYKKERI
1918

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SERIE: PLANKTON

BIND I

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KOMMISSIONEN FOR HAVUNDERSØGELSER

SERIE: PLANKTON

BIND I

KØBENHAVN
I KOMMISSION HOS C. A. REITZEL
BIANCO LUNOS BOGTRYKKERI
1904—1918

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MEDDELELSER FRA KOMMISSIONEN FOR HAVUNDERSØGELSER
SERIE: PLANKTON · BIND I · NR. 13 · 1918

PLANKTON

AND OTHER

BIOLOGICAL INVESTIGATIONS

IN THE SEA AROUND THE FÆROES IN 1913

BY

OVE PAULSEN

WITH 6 FIGURES IN THE TEXT

KØBENHAVN
I KOMMISSION HOS C. A. REITZEL
BIANCO LUNOS BOGTRYKKERI
1918

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In the spring of 1913, the schooner "Margrethe" was despatched by the Danish Commission for Investigation of the Sea to the Færoes. The object of the cruise, apart from scientific investigations, was to test the capabilities of the vessel, which was fitted with auxiliary motor, but had not yet been fully equipped for research work. The present writer took part in the cruise, as planktonologist, from the 15th May to 21st June, and shortly after this latter date, the "Margrethe" commenced a new cruise, to the West Indies, where it ran aground about the end of December.

The following pages contain the report of my investigations during the time I was on board. The weather was stormy, and only rarely were we able to put out to sea, being for the most part forced to lie at anchor in a sheltered fjord, Trangisvaag, and most of the investigations were consequently made in that water.

I. DISTRIBUTION OF THE LAMINARIA FORESTS IN TRANGISVAAG FJORD.

In the biological study of a given area of sea, it is not only necessary to know the animals which live there and devour the organic matter: it is also important to know what plants produce the matter devoured. Among these, we have primarily the plankton, and next multicellular plants, which live attached to the sea floor. These latter play a dual part in the economy of the water. On the one hand, their decomposition produces detritus — and it has been shown by C. G. Joh. Petersen and P. Boysen Jensen that *Zostera* detritus is an important item in the food of marine animals in Danish waters — while on the other hand, they form submarine forests where the animals may hide, feed on the plants, or prey on each other or on on the herbivorous forms, and where the water also must be presumed to be rich in oxygen.

When the "Margrethe" was lying at the Færoes in the spring of 1913, where it was proposed to investigate the Trangisvaag Fjord, I therefore determined, in addition to my principal work, the plankton investigations, to endeavour also to obtain a survey of the marine algal vegetation of the fjord. With this end in view, I hired a motor boat and a native fisherman, and with these and a triangular dredge having a line furnished with marks for reading the depth, I made, in the course of some few days, a total of 115 hauls at various parts of the fjord. The hauls were at once marked off by landmarks upon a small copy af a chart which I had with me, and the contents examined and noted on the spot. Sometimes algæ or animal forms were brought back for further investigation, but as a rule, the whole mass was thrown overboard again before making the next haul. In this way, it was possible to push forward the work at a rapid rate, though the weather offered obstacles in the form of storms and showers of rain.

Obviously, an investigation of this sort cannot yield any thorough knowledge of the algal vege-

tation, but this was not intended. My object was to determine the distribution of the *Laminaria* species and the larger algæ found together with them, which form the forests of the sea floor.

For the algal vegetation of the Færoes, reference may be made to BØRGESEN, who has published a systematic list, and also given a description of the vegetation.[1] It will here suffice to note that the litoral communities of *Ascophyllum, Fucus, Enteromorpha,* etc., lying above low water mark, were here entirely disregarded. Outside these, we have the *Laminaria,* nearest land as a rule *L. hyperborea,* to which is added, at a depth of abt. 2 metres, *L. færoënsis,* the latter at times predominating. Among species frequently found together with these may be mentioned: *Ulva lactuca, Enteromorpha clathrata* (these in low water), *Desmarestia aculeata, Ceramium, Chorda filum, Porphyra, Furcellaria fastigiata, Ptilota plumosa, Rhodymenia palmata, Polysiphonia, Desmarestia viridis, Callophyllis laciniata, Lomentaria clavellosa.*

The community which these plants combine to form corresponds approximately to BØRGESEN'S *Laminaria* community, the *Laminaria* being constantly predominant. According to BØRGESEN, *L. færoënsis* is only met with where there is no strong current in the water. Where the current is strong, its place is taken by *L. hyperborea.* This agrees with the fact that the latter species is in Trangisvaag as a rule found closer in to land than the former. The stock of other algæ is highly variable; this I have not further investigated, but have merely noted the species where they occurred.

Fig. 1.
Trangisvaag as seen from a point near Helleaa.

This *Laminaria* community appears as an unbroken belt along the coast of the true Trangisvaag (Inderfjorden, the narrow inner fjord; see chart p. 5). In the outer and middle parts of this section of the fjord, it extends out to a depth of abt. 20 metres, but in the inner part it does not run so deep. At the innermost base of the fjord, close to the mouth of Storaa, we have at 6 metres' depth a limit between pebbles (gravel) and mud, the latter naturally lying deeper. The *Laminaria* are everywhere but few and small: in addition, we also find *Desmarestia aculeata, Ulva, Ceramium* and *Chorda.* On mud bottom however, there are fewer, owing to the scarcity of suitable objects (stones, shells) for attachment. A little farther out in the fjord, the *Laminaria* cease, the boundary lies at about 12 m. Outside this limit, we encounter a black mud, stinking of sulphuretted hydrogen, with dead fragments of algæ. This bottom continues right out through the fjord, but with deeper and deeper water, the *Laminaria* community at the same time going deeper down as we pass out from the inner end, the base, of the fjord. Whether this difference of level in the case of the *Laminaria* is due to the mud, or to variation in the clearness of the water near and away from the mouth of Storaa, I do not know.

In the middle and outer part of the true inner fjord, the inner limit of the mud very nearly coincides with the outer limit of the *Laminaria,* the limit in question lying at abt. 20 metres' depth. The *Laminaria* are attached to stones, or at times to shells, which are abundant, and close in to shore they fix themselves to the rocky bottom.

In the outer part of the inner fjord, and in the outer fjord itself, (see chart) a change is apparent, the bottom in the deepest channel being no longer muddy, but giving place gradually to a fine black

[1] F. BØRGESEN: The Marine Algæ of the Færoes. (Botany of the Færoes II.) Copenhagen 1902. F. BØRGESEN: The Algæ-Vegetation of the Færoese coasts, with remarks on the phyto-geography (Botany of the Færoes III.) Copenhagen 1908.

Trangisvaag
Tveraa
Frodebo Nipen
Frodebo
Helmnar
Rock
Mud
Shells and gravel
Sand
Stones
Limit of Laminariae
— shows direction of hawl
54 etc. No. of station
TRANGISVAAG - FJORD
SUDERÖ
5 metres
10
20

Fig. 2.

sand, and then again to coarse sand. Red algæ are found here at times, e. g. *Rhodophyllis dichotoma, Odonthalia dentata, Delesseria sinuosa, Plocamium coccineum.* At the same time, the character of the *Laminaria* community also changes, *Alaria esculenta* being now predominant in the upper part, where the action of the waves is heavy; the *Laminaria* can here only live in deeper water.

The results of my dredge hauls are shown in the accompanying chart (fig. 1) on which are noted:

Depth curves (5, 10, 20 m.).

Nature of bottom (Rock, stones, shell gravel, sand or mud).

Hauls.

Limits of the Laminaria community, as far as could be determined by the hauls.

In the outer part of the fjord, as in Oerdevig and Tjaldevig, I had not time to make a sufficient number of hauls, and the *Laminaria* limit noted on the chart is therefore somewhat doubtful in certain places from these parts of the fjord, but as the hauls are also noted on the chart, the reader may easily form an idea as to the accuracy of the limit as drawn.

As regards the inner part of the fjord, however, I belive that the *Laminaria* limit here noted is correct in all essentials. It shows that by far the greater part of the bottom of the fjord is covered by *Laminaria* forests, and that outside these, in the deepest water, the bottom is of mud, without *Laminaria*, but with some few red algæ at times.

The fauna of the *Laminaria* forests is very different from that outside them. Though not a zoologist, I will venture to put forward some observations on this head, referring for the rest to a comprehensive work by an expert on the subject, which it is hoped will shortly appear.

On the mud-covered bottom of the fjord, I have encountered the following species: *Abra (nitida* or *prismatica) Cardium echinatum, Axinus flexuosus* and various vermes, e. g. *Nephthys coeca, Pectinaria, Nereis pelagica.* Among the *Laminaria*, one mollusc of the genus *Trochus* was particularly common; of other molluscs, *Astarte (Montagui* or *elliptica), Aporrhais pes pelicani, Modiola modiolus* and *Buccinum undatum.* In addition, crustaceans were met with in masses: *Mysis inermis, Hyas araneus, Galathea vexa, Crangon Allmani, Spirontocaris Gaimardi, Pandalus Montagui, Gammarus locusta, Idothea baltica, Iphimedia obesa, Hippolyte varians, Gastrosaccus, Eupagurus Bernhardus;* of fishes, *Centronotus gunellus, Gobius Ruthensparri,* and *Gadus virens,* — small specimens of the last-named species in particular were numerous. Larger fish also were found preying in the weed growths; in open spots covered with *Ulva,* between the *Laminaria,* one could see large cod (?) hovering motionless, but dashing off as soon as they perceived the boat.

Many of the small animals mentioned were also found in the stomachs of fish taken in Trangisvaag, see below.

Besides animal specimens, a number of bottom samples were brought home, the diatoms in which have since been examined by Hr. cand. polyt. E. Østrup. The 11 samples contained 76 salt-water species, mostly coastal forms, 33 fresh-water species, and 4 brackish. A list is given below; it will be noticed that many species were only found in one sample.

SALT-WATER SPECIES

(Where not otherwise stated, the species has been found in one sample only).

Achnanthes longipes Ag.
Actinocyclus subtilis (Greg.) Ralfs, mostly small.
Actinoptychus undulatus (Bail.) Ralfs. 10 samples.
Amphora angusta (Greg.) Cl. var.
— *arenicola Grun.*
— *crassa Greg.*
— *Græffei (Grun.) Cl.* 3 samples.
— *Proteus Greg.* 4 samples.
Amphora Terroris Ehr.
[— sp. A. S. Atl. Tab. XXVII, fig. 43 (Camp. Bay)]
Biddulphia antediluviana (Ehr.) pl. V. H. 2 samples.
— *obtusa (Ktz.) Ralfs.*
Caloneis brevis (Greg.) Cl.
— *Liber (W. Sm.) Cl. genuina.*
— *sejuncta (A. S.) Cl.*
Campylodiscus Thureti Bréb. 3 samples.
Chætoceras decipiens Cl.
Cocconeis costata Greg. 3 samples.
Cocconeis pseudomarginata Greg. 3 samples.

Cocconeis Scutellum Ehr. 3 samples.
— *stauroneiformis W. Sm.* 3 samples.
— *fasciculatus O. M.*
— *marginatus Ehr.*
— *radiatus Ehr.* 4 samples.
— *sp.* Fragments. 7 samples.
Dimeregramma distans (Greg.) Ralfs.
— *dubium Greg.*
Diploneis Bombus (Ehr.) Cl. 3 samples.
— *borealis (Grun.) Cl.*
— *chersonensis (Grun.) Cl.*
— *Crabro (Ehr.) Cl.* 3 samples.
— *fusca (Greg.) Cl.* 3 samples.
— *interrupta (Greg.) Cl.* 3 samples.
— *lineata (Dank.) Cl.*
— *Papula (A. S.) Cl.*
— *Smithi (Bréb.) Cl.* 4 samples.
— *vacillans (A. S.) Cl. v. delicatula Cl.* 3 samples.
Glyphodesmis lanceolata Ph.
— *Williamsoni (Greg.) Grun.*
Grammatophora angulosa Ehr. v. islandica Ehr. 4 samp.
— *marina (Lyngb.) Ktz.* 7 samples.
— *serpentina Ralfs.* 6 samples.
Isthmia nervosa Ktz. 7 samples, fragments only.
Navicula abrupta Grun.
— *directa W. Sm.*
— — *v. remota Grun.*
— *distans (W. Sm.) Cl.* 8 samples.
— *forcipata Grev.*
— *Hennedyi W. Sm.*
— *inornata Grun.* 2 samples.
— *Lyra Ehr.*
— *palpebralis Bréb. var.*
— *rhombica Greg.* 3 samples.
— *spectabilis Greg.* 2 samples.
Nitzschia angularis W. Sm. 3 samples.
— *distans (W. Sm.) Cl.*
— *littoralis Grun.* 3 samples.
— *paradoxa Grun.* 2 samples.
— *punctata (W. Sm.) Grun.* 6 samples.
— *Sigma (Ktz.) W. Sm. v. valida Cl. & Grun.* 2 samp.
Paralia sulcata (Ehr.) Ktz. 10 samples.
Plagiogramma elongatum Grev.
Pleurosigma elongatum W. Sm. 4 samples. (Previously known from cleanings of shells from South America; Greville in Transact. micr. soc. 1896, p. 121).
— *longum Cl.*
— *Normani Ralfs.* 2 samples.
Podosira hormoides Mont.
Rhabdonema arcuatum (Ag.) Ktz. 5 samples.
— *minutum Ktz.* 4 samples.
Rhaphoneis Surirella (Ehr.) Grun.
Scoliopleura tumida Bréb. (= Navicula tumida).
Surirella fastuosa Ehr. 2 samples.
Synedra affinis Ktz. 2 samples.
Trachyneis aspera (Ehr.) Cl. genuina Cl. 2 samples.
— — *v. intermedia Grun.* 3 samples.
— — *pulchella W. Sm.*

Of the above named salt-water genera *Cocconeis* is fixed upon algæ, *Grammatophora, Isthmia* and *Rhabdonema* are fixed in chains. Almost all of the other species are to be regarded as coast forms.

FRESH-WATER SPECIES.

Anomoeoneis serians Bréb.
— — *f. minor.*
Cymbella Cistula Hempr.
— *lanceolata Ehr.*
— *parva W. Sm.* 6 samples.
— *sp.* 3 samples.
Diatoma hiemale (Lyngb.). Heib.
Diatomella Balfouriana Grev.
Diploneis elliptica (Ktz.) Cl.
— *ovalis (Hilse) Cl. v. oblongella Nægeli.* 2 samples.
Epithemia Zebra (Ehr.) Ktz. 5 samples.
Eunotia major (W. Sm.) Rabh.
— *prærupta Ehr.*
— *sp.* 3 samples.
Gomphonema acuminatum Ehr.
— *geminatum Lyngb.*
Melosira italica O. M.
Meridion circulare Ag. 4 samples.
Navicula rhyncocephala Ktz.
— *viridula Ktz.*
Nitzschia sigmoidea W. Sm.
Pinnularia alpina W. Sm. 4 samples.
— *lata Bréb.* 2 samples.
— *major Ktz.* 2 samples.
— *sp.* 4 samples.
Rhoicosphenia curvata (Ktz.) Grun. 4 samples. Fresh and brackish.
Rhopalodia gibberula (Ehr.) O. M. v. rupestris W. Sm.
Synedra Ulna (Nitzsch) Ehr. 7 samples.
Tabellaria fenestrata (Lyngb.) Ktz. 2 samples.
— *flocculosa (Roth.) Ktz.* 5 samples.
Tetracyclus emarginatus W. Sm.

BRACKISH-WATER SPECIES.

Amphora ovalis Ktz.
Nitzschia acuminata (W. Sm.) Grun.
— *Sigma W. Sm.* 5 samples.
Scoliopleura Personis Grun. 3 samples.

II. PLANKTON INVESTIGATIONS IN TRANGISVAAG FJORD.

The Fjord had its own neritic plankton, differing from that found in the water outside, though this also was neritic.

In order to understand how such a little narrow fjord can be an independent plankton-producing area, it is necessary first of all to glance at the hydrographical conditions. An independent plankton area must of course have a water mass of its own, renewed either slowly or not at all. The renewal of water in Trangisvaag Fjord takes place in two ways. In the first place, fresh water is introduced by streams and rivers; of these latter, Storaa, which flows out into the base of the fjord, is by far the most important. In the second, this continual inflow of fresh water must involve a corresponding outflow of fjord water into the open sea, from which again salt water is carried by the currents, — the tidal current for instance — into the fjord. The first head then, comprises only inflow of fresh water, whereas the second includes the interchange of water between the fjord and the open sea.

As regards the introduction of fresh water, J. P. JACOBSEN has shown[1] that "this fresh water becomes so strongly mixed with the water of the fjord itself, even within stations 3, 4 and 5, that the surface salinity for these stations generally does not differ by more than abt. 3 ‰ from that for the outermost, deep water of the fjord, while the bottom salinity at the mentioned stations is never more than 0·1 ‰ different from this". The surface salinity at these stations varied, during the period from 3—16 June, between 25·94 and 35·03 ‰, whereas at the bottom, at abt. 13 m. depth, it was nearly always 35·10 ‰. Farther out in the fjord, the surface salinity increases, rising at the extreme outer and wider part to 35 ‰ or more. This layer of fresher water, however, was only some few metres thick, giving place below to water of about the same salinity as that outside the fjord, viz. abt. 35·14 ‰.

This state of things is what is usually met with where fresh water flows out into a fjord, and it would be natural to expect an outward movement of the surface water, while the bottom water moved inward. These currents, JACOBSEN found, were "very slight, if indeed any such existed" — they were indeed hardly discernible at all by ordinary current measurements.

As regards the other point, the interchange of water between the fjord and the open sea, we have no very exhaustive records to draw upon. JACOBSEN supposes 1 metre to be the difference between highest and lowest water, and calculates from this what current would be required to effect this difference. And with regard to the effect of the tide, he comes to the following conclusion: "It is unlikely that it should be of any great importance, as regards the mixing of water in the fjord". The tidal currents outside the fjord are, nevertheless, as we know, very strong, and might possibly give rise to currents in the fjord itself. JACOBSEN has not, however, found that any such exist. — There remain then, currents due to the action of the wind; these can be strong, and may be in- and outflowing simultaneously. JACOBSEN states, with regard to these, "there can be no doubt that the heavy storms which are of so frequent occurrence form the principal factor in the renewal of the water in the fjord."

Summing up the foregoing, we may say, that no strong currents have been shown to exist in Trangisvaag Fjord, and that such probably do not exist under normal conditions. The fjord water is thus renewed quite slowly, and the fact that the fjord has its own plankton supports this view. Possibly the water is at times suddenly renewed during storms.

[1] J. P. JACOBSEN: Hydrographical Investigations in Færoe waters. (Medd. fra Kommissionen for Havundersøgelser, Ser. Hydrografi, II, No. 4) Copenhagen 1915.

[2] These stations lie up in the fjord, only abt. 600 m. from the innermost land (see chart).

The plankton investigations in Trangisvaag were carried out partly be means of a plankton net, and partly by GRAN's method. The plankton nets used were a small NANSEN net, diam. 44 cm, No. 20 gauze, and a large egg net, diam. 1 m, of no. 3 gauze. GRAN's method [1] is as follows: a sample of sea water is taken and the plankton centrifuged out, and then examined in a fresh state. Where this last is impracticable — and it was not always easy on board the "Margrethe", which was not equipped for marine investigations — the sample can be preserved by addition of a small quantity of FLEMMING's liquid. I examined on board nearly all the net samples, and several water samples were also centrifuged and their plankton content investigated on the spot. Otherwise, the water samples taken were put into bottles containing 250 ccm, with glass stoppers, and the plankton subsequently investigated at home. — As we had but a limited number of such bottles, and as some were used for investigations on the Færoe Bank, I had only a few at my disposal in Trangisvaag. The method of using these was as follows. At a given spot in the fjord, to wit, off Tveraa, a water sample was taken each day, in the morning, when the "Margrethe" lay there. The sample was taken with PETTERSON's water bottle at 10 m depth, and the salinity and temperature were determined at the same time. The object in taking these samples was to investigate the fluctuations in the plankton at the same place within a short period. The first sample was taken on the 28th May, the last on the 16th June. The result of the plankton counts in these samples will be seen from Table I. As the samples were very rich in plankton, I did not consider it necessary to count more than 10 ccm of each, and on checking the counts, it was found that no essential error had been made; highly divergent figures were only found in the case of the rarer species.

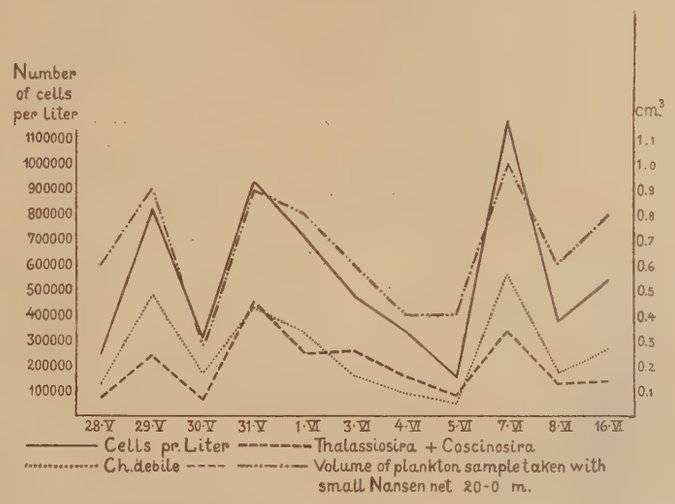

Fig. 3.
Curves showing quantity of plankton (number of cells pr. litre and for one of the uppermost curves, volume) off Tveraa.

It will be seen that the plankton of the fjord is a typical neritic plankton, characterised particularly by *Chætoceras debile* and *Thalassiosira Nordenskiöldii;* of species constantly found there were also *Chætoceras decipiens* (rare), *Diadema* and *simile, Fragilaria oceanica, Leptocylindrus danicus* (abundant), *Nitzschia delicatissima* (frequent), *Skeletonema costatum* (frequent), *Thalassiosira gravida* (+ *Coscinosira polychorda;* the two species are difficult to distinguish one from another when the chains are broken) (abundant), *Thalassiothrix nitzschioides* (rare), *Distephanus speculum* (rare), *Gymnodinium Lohmanni* (?), (rare), *Peridinium færoënse* (rare), *Mesodinium sp.* (rare).

As regards the species composing the plankton, there is no change of any importance to be noted in the three weeks within which the samples were taken, with the exception of the last sample of all. The quantity, however, was found to be subject to considerable variation. At the top of Table I will be seen the number of cells per litre for all species, and it is on the basis of these figures that the fully drawn curve in fig. 3 was constructed. Almost exactly the same course is followed by the uppermost of the dotted curves in the same figure. This shows the volumes of plankton samples, taken at the same time as the water samples, with a small NANSEN bag, vertically from 20 to 0 metres

[1] H. H. GRAN: Preservation of samples and quantitative determination of the plankton. (Publications de circonstance, No 62) Copenhagen 1912. H. H. GRAN: The Plankton production of the north European waters in the spring of 1912. (Bull. planktonique, publ. par le bureau du Conseil). Copenhagen 1915.

Table I. PLANKTON FROM TRANGISVAAG OFF TVERAA.

Number of cells per litre. GRAN's method.

Nr.	36	37	38	39	40	42	43	44	45	46	74
Date (1913)	28·V	29·V	30·V	31·V	1·VI	3·VI	4·VI	5·VI	7·VI	8·VI	16·VI
Depth (Metres)	10	10	10	10	10	10	10	10	10	10	10
Temperature (C°) 0 m.	7·77	8·55	8·60	8·20	8·02	8·70	8·20			7·75	8·20
— — 20 —	7·49	7·60	7·54	7·57	7·60	7·70	7·70			10 m.	10 m.
Salinity (‰) 0 m.	34·94	35·10	34·88	34·70	34·76	35·10	35·84				
— — 20 —	35·16	32·65	35·14	35·14	35·07	28·66	35·15				
Ccm. examined	50	10	10	10	10	10	10	10	10	10	10
Total number of cells per litre	245904	819300	304100	917800	715200	486300	338100	167400	1155500	379200	515300
Diatomaceae.											
Actinoptychus undulatus (Bail.)	40	....	....	....	....	....	....	100			
Cerataulina Bergonii Perag.	....	....	....	1000							
Chaetoceras boreale Bail.	....	....	....	....	....	....	....	....	....	....	600
— constrictum (Gran)	80	2400	500	....	1600						
— contortum Schütt	160	....	1200	800							
— debile Clev.	119300	483700	163500	437600	328200	154200	98400	47300	572000	178400	281000
— decipiens Clev.	360	700	400	600	....	200	300	100	1500	200	3800
— Diadema (Ehrh.)	1040	3300	200	2000	3400	200	....	100	1000	400	
— laciniosum Schütt.	....	....	....	800	400	....	1200	....	3000		
— simile Clev.	?	10800	5900	6600	8000	4600	1300	1500	2000	600	1800
— teres Clev.	40	....	....	....	400	....	100	100			
Coscinodiscus excentricus A. Schm.	40										
— marginatus Ehrh.	80	....	100								
Fragilaria islandica Grun.	80	2000	700	1600	800	1000	1200	100	....	200	
Lauderia borealis Gran	....	....	200								
Leptocylindrus danicus Clev.	3640	8300	4600	14400	15200	10200	10500	9600	43500	17800	10400
Nitzschia Closterium W. Sm.	720	1000	900	600	2400	400	500	200	1000	600	400
— delicatissima Clev.	11520	23200	11800	38000	24000	17200	8000	4900	47500	10800	1600
— seriata Clev.	900	1600	1600	1500	1300	2400	1900	1500	4200	5200	46400
Paralia sulcata (Ehrh.)	400	1400	600	....	....	2000	....	600			
Rhizosolenia semispina Hens.	560	100	100								
Skeletonema costatum (Grev.)	11160	26200	14600	41000	39400	31800	26600	12900	87000	33000	
Thalassiosira gravida[1] Clev.	1640	13100	6200	14800	15200	7000	6500	3500	26000	7000	22600
— Nordenskiöldii Clev.	83600	232500	82300	444600	251400	253200	168200	78700	345500	120200	143000
Thalassiothrix nitzschioides Grun.	680	900	900	400	400	1000	....	300	....	....	200
Licmophora sp.	....	200	100	....	....	400	200	....	....	200	
Pleurosigma sp.	....	....	200	....	200						
Other bottom diatoms	1960	2900	3600	4000	8400	3400	4700	3200	15000	7400	
Silicoflagellata.											
Distephanus speculum (Ebbg.)	160	200	300	400	600	400	100	....	1500	....	200
Peridiniates.											
Dinophysis rotundata Clap. L.	....	....	....	....	....	200					
Gonyaulax triacantha Jørgs.	40	....	100	200	....	....	100	100	....	....	200
Gymnodinium Lohmanni Pauls. (?)	240	....	300	600	400	200	400	300	500	200	
Heterocapsa triquetra (Ehbg.) Stein	80										
Peridinium brevipes aff.	80	....	200	....	....	200					
— conicum Gran	....	....	....	....	....	....	....	....	....	....	200
— faeroënse Pauls.	1040	1400	600	2000	1600	1000	100	700	1000	....	1000
Peridinium asymmetricum (Mang) Ostf.	40	....	100								
— minusculum Pavill.	40	....	100	200	....	....	....	100	500	....	200
— pellucidum Gran	....	....	....	....	....	....	....	100			
— sp.	520	....	400	....	200	1000	200	400	1500	200	800
Cystae of Peridinia	200	400	400	1400	600	100	300	500			

[1] incl. Coscinosira polychorda.

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Depth (Metres)	10	10	10	10	10	10	10	10	10	10	10
Temperature (C°) 0 m.	7·77	8·55	8·60	8·20	8·02	8·70	8·20			7·75	8·20
— — 20 —	7·49	7·60	7·54	7·57	7·60	7·70	7·70			10 m.	10 m.
Salinity (‰) 0 m.	34·94	35·10	34·88	34·70	34·76	35·10	35·84				
— — 20 —	35·16	32·65	35·14	34·14	35·07	28·66	35·16				
Ccm. examined	5·0	10	10	10	10	10	10	10	10	10	10
Total number of cells per litre	245904	819300	304100	917800	715200	486300	338100	167400	1155900	379200	515300
Protozoa.											
Cyttarocylis denticulata (Ehbg.)	40	....	200								
Laboea conica Lohm.	....	....	....	....	....	....	100				
— strobila Lohm.	....	....	....	....	200						
— sp.	320	300	300	....	200	....	....	100	500	....	400
Mesodinium sp.	....	....	500	200	600	400	200	100	500	400	
Tintinnopsis sp.	165	200	300								
Tintinnus subulatus Ehbg.	....	....	100	400	....	300	....	400	....	600	
Infusoria cetera	3320	1500	700	1000	3200	700	700	300	1000	400	400
Metazoa.											
Nauplius	....	....	....	....	....	....	....	....	....	.. .	100
Scales of butterflies	1280	700	300								
Excrements?	1120	1900	200	600	8200	4000	8200	400	3500	600	

depth, and measured with the JACOBSEN-PAULSEN apparatus for measuring the volume of plankton. (Medd. Komm. for Havundersøgelser, Ser. Plankton. Bd. I No. 11).

These corresponding curves show, that there were three plankton maxima, viz. 29 May, 31 May and 7 June, the figures being 819300, 917800 and 1155500 cells per litre respectively. Between these maxima lay minima with 304100 and 167400 cells per litre, i. e. figures far below the maximal. These considerable fluctuations in quantity are due to dilution or concentration of the entire plankton mass, and not to increase or decrease in the numbers of any single component (species). The separate species show in the main the same fluctuations as the entire mass of the plankton. The two lowest dotted curves in fig. 3 show the fluctuations in two of the commonest species, *Chætoceras debile* and *Thalassiosira Nordenskiöldii*, and it will be seen that they follow the main curves, while the same applies, at any rate in main features, to the four curves in fig. 4, showing the variation in numbers of *Nitzschia delicatissima*, *Skeletonema costatum*, *Thalassiosira gravida* (+ *Coscinosira polychorda*) and *Leptocylindrus danicus*. Similar curves with three maxima are shown by *Chaetoceras decipiens* and *Peridinium færoënse*.

As mentioned above, the last sample, that of the 16th June, was the only exception from the whole, presenting in some degree a qualitative difference as compared with the other samples; it should also be noted, that 8 days had elapsed between the taking of this last sample and the last but one, whereas the longest interval between any two of the remaining samples was two days. This last sample has a greater quantity of *Chætoceras decipiens* and *Nitzschia seriata* than any of the others, viz. 3800 and 46400 per litre respectively. It also showed 600 *Chætoceras boreale*, a species which is lacking in the other samples, whereas *Skeletonema*, which was present in the others, is here lacking. In the course of eight days, then, a not inessential qualitative change has taken place in the plankton of the fjord.

As to the cause of these alterations we can say nothing. The quantitative fluctuations may be due to a change in the entire plankton of the fjord, e. g. by the introduction of new plankton from without, or to a dilution, or to the fact that the plankton was not evenly distributed throughout the water, but packed in clouds. In the latter case, the maxima found would have been produced by the sample having

been taken from one such cloud, while the samples giving minimal figures were taken from the thinner plankton between the denser masses. The question could be solved by taking simultaneous samples at various parts of the fjord, and this may, it is hoped, be done on a subsequent occasion.

On three different days, viz. 29 May, 6 and 16 June, hydrographical and biological "longitudinal sections" were taken from the "Margrethe" in Trangisvaag Fjord, a series of stations being made from the innermost portion of the fjord to the water quite outside it. (See chart fig. 5, where the stations are marked). At each of the stations, a vertical haul was made from 10 to 0 m, with the little fine-meshed Nansen net, and one with the large, wide-meshed egg net. At the deeper stations, moreover, a deeper vertical haul was also made. Unfortunately, I had not sufficient bottles to take Gran-samples at these stations, but as the net hauls were made in the same way at all the different stations, (the nets were carefully washed after each haul) the plankton from the different stations will be fairly comparable. In Table II, the plankton from these three "longitudinal sections" is indicated by means of the usual symbols, subjectively estimated. Countings of net hauls being, as we know, subject to several sources of error (LOHMANN) I did not consider it worth while to count the plankton from these hauls. Nevertheless, in order to have some comparable figures, I have selected some of the commonest microplankton species, and counted these in three series of samples. (For the macroplankton see below). Table III shows the results of these counts; in the third horizontal row is noted what quantity of the sample was counted; but these fractions do not as a rule apply to *Chætoceras debile*, this species being so numerously represented in most of the samples that a considerable further dilution was required. — The figures in Table III indicate the number of cells in the whole sample. A column of water 44 cm in diameter and 10 m high contains abt. 1520 litres, so that it is easy to calculate the quantity per litre. The figures obtained by this method, however, are too small; far smaller than those found for the Gran-samples. The net has thus thrust a quantity of water before it, and consequently filtered considerably less than 1520 l. I have therefore not attemped to make any comparison between the Gran-samples and the net samples, but had to be content with comparing the figures obtained within each group.

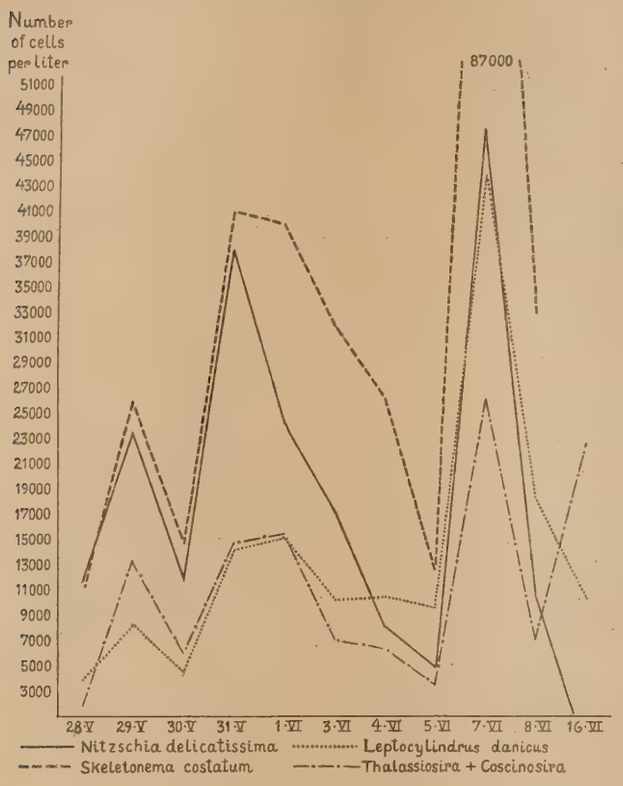

Fig. 4.
Curves showing number of cells pr. litre of different species in plankton of Tveraa.

Table IV shows the results of a count of the macroplankton, in the three sections; $^1/_{20}$th of each sample was counted.

An examination of Tables II, III and IV reveals the following:

1. In the list of species composing the plankton, there is no difference to speak of between the three series of samples, each considered as a whole. All three contain the same species.

2. As regards quantitative differences between the three sections, we notice that I (29 May) has a far richer plankton than the two others, both for micro- and macroplankton. The 29th May was also a plankton maximum at Tveraa (cf. fig. 2). Especially high figures in Section I are found for *Chæto-*

Table II. PLANKTON FROM STATIONS FORMING 3 "LONGITUDINAL SECTIONS" OF TRANGISVAAG.

Vertical hauls with Nansen-net.

	Longitudinal section I May 29th											Longitudinal section II June 6th					Longitudinal section III June 16th				
Nr.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Station	8	9	11	12	13	13	14	17	17	18	18	9	11	17	17	18	8	11	17	17	18
Vertical Haul, Depths (in M.)	10—0					22—14	10—0		25—13.5	10—0	35—25	10—0			30—15	30—0	10—0			30—15	30—0
Quantity of the plankton (cm³)	0·7	1·0	0·8	1·2	1·4	0·3	0·7	0·3	0·1	very small		0·7	—	very small			0·8	0·8	0·5	0·2	0·6
Cerataulina Bergonii Perag.	..	..	..	..	rr	..	rr	..	..	..	rr	rr	..	rr	rr	r	rr	..	rr	rr	rr
Chaetoceras atlanticum Clev.	..	..	..	..	..	rr	..	..	.	rr											
— boreale Clev.	..	..	..	..	rr	..	..	r	r	rr	rr	..	..	rr	..	rr	..	rr	rr	r	r
— constrictum Gran.	r	r	..	+	rr	rr	rr	rr	rr	rr	rr	rr	..	..	r	..	..	..	..	rr	
— contortum Schütt.	+	+	..	..	..	r	r	r	..	rr	..	r	r	r	rr	+	+	rr	r	+	rr
— convolutum Castr.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	..	..	rr
— debile Clev.	cc	cc	cc	cc	cc	cc	cc	cc	c	r	r	cc	cc	c	c	c	cc	cc	c	c	+
— decipiens Clev.	r	r	+	+	+	+	+	r	r	r	+	+	+	+	+	c	r	+	c	+	c
— Diadema (Ehbg.) Gran.	r	+	+	+	r	r	r	r	+	rr	..	r	+[1]	r	r	..	r	r	r	r	
— laciniosum Schütt.	rr	..	rr	..	..	..	..	..	..	rr	rr	..	..	..	r	..	..	..	r		
— simile Clev.	c	+	+	+	+	rr	+	+	r	rr	rr	r	..	r	r	r	r	r	..	..	rr
— teres Clev.	r	rr	..	r	rr	rr	r	rr	+	+	+	..	..	r	+[1]	rr[1]	..	rr	r	rr	
Corethron criophilum Castr.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	rr	rr
Coscinodiscus excentric. A. Schm.	..	..	..	..	..	..	..	..	..	rr	rr	..	..	..	..	rr					
— marginatus Ehrh.	rr	..	rr	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	r		
— radiatus Ehrh.	..	rr	rr	..	rr	r	rr	rr	+	r	r	r	..	..	r	r	rr	rr			
— subbuliens Jørgs.	..	..	..	..	..	..	..	..	r	..	rr	..	..	rr	rr	rr	..	..	..	..	r
Coscinosira polychorda Gran.	r	+	r	..	rr	+	+	r	rr	..	..	r	r								
Fragilaria islandica Grun.	r	+	+	r	r	r	+	r	+	r	r	+	+	r	r	r	+	+	+	rr	
Leptocylindrus danicus Clev.	+	+	+	+	+	+	+	+	+	r	rr	+	c	+	+	+	+	c	+	r	rr
Nitzschia delicatissima Clev.	c	+	+	+	+	r	+	..	..	..	..										
— seriata Clev.	+	+	+	+	+	+	+	+	r	r	r	c	+	+	+	c	cc	cc	cc	cc	cc
Rhizosolenia alata Btw.	..	rr	..	..	..	..	..	..	..	rr	..	..	..	rr	r	..	rr	rr	rr		
— semispina Hens.	..	..	..	..	..	..	..	..	..	..	..	..	..	.	..	..	rr	rr	r	r	rr
— Shrubsolei Clev.	..	..	rr	..	..	..	rr	rr	..	..	rr	rr	rr	..	rr	rr	..	rr	rr	rr	rr
— styliformis Btw.	..	..	..	..	..	..	..	..	r	r	..	..	..	..	..	..	rr	..	..	..	r
Skeletonema costatum (Grev) Grun.	+	r	r	r	r	..	..	rr	..	..	..	r	r	r	r	r	r	r	r	rr	
Thalassiosira gravida Clev.	c	c	c	c	c	r	r	r	r	r	..	c	+	+	+	r	c	c	c	+	+
— Nordenskiöldii Clev.	cc	c	c	cc	cc	+	c	+	r	rr	rr	c	cc	+	r	r	c	c	c	r	r
Thalassiothrix nitzschioides Grun.	..	rr	..	r	r	r	r	r	r	rr	rr	+	+	..	+	+	r	+	r	rr	r
Ceratium arcticum Ehbg.	..	..	..	..	..	rr	..	rr	..	..	..	..	..	..	..	rr					
— longipes (Bail.) Clev.	..	..	..	..	..	..	..	..	..	rr	rr										
— tripos (O. F. Mül.) Nitzsch.	..	..	..	..	..	..	..	..	..	rr	..	..	..	..	..	..	..	..	rr		
Peridinium faeroënse Pauls.	rr	..	..	..	..	..	..	..	..	..	..	r	..	..	..	..	rr				
Phaeocystis Pouchetii Lag.	+	..	r	+	rr	r	r	r	..	..	..	+	r	..	..	rr	..	..	r	rr	r
Tintinnus subulatus Ehbg.	..	..	..	..	..	rr	rr	..	..	..	..	+	r	..	..	..	+	r	rr		
Cirridped larvae	..	rr	rr	rr	..	rr	rr	rr	rr	r	r	..	..	..	r	rr					
Evadne Nordmanni Lovén.	..	rr	..	rr	..	..	..	..	..	..	..	r									
Podon Leuckartii G. O. Sars	..	r	rr	rr	rr	rr	..	rr	rr												
Acartia longiremis (Lilj.) G.O.Sars	rr	r	rr	rr	rr	rr	rr	..	rr	rr	..	rr	..	rr	rr	..	..	rr	rr	..	rr
Oithona similis Claus	..	..	..	..	..	..	..	..	rr	..	rr										
Nauplius	..	rr	rr	..	rr	rr	..	r	rr	r	rr	rr	..	rr	rr	rr	rr	r	..	rr	rr
Larvae of snails	..	..	rr	rr	..	..	..	..	..	..	..	..	rr								
Larvae of mussels	..	..	rr	..	..	rr	..	..	..	rr	..	..	..	..	..	rr	..	..	r	..	rr

[1] With spores.

Also observed:

Halosphaera viridis Schmitz. No. 3 rr.
Hexasterias problematica Cl. No. 10 rr, 15 rr, 16 rr, 21 rrr.
Pachysphaera pelagica Ostf. No. 6 rr.
Actinoptych. undulat. (Bail.) No. 14 rr, 16 rr.
Bacillaria paradoxa Gmel. No. 17 rr.
Coscinodiscus concinnus W. Sm. No. 13 rr.
Grammatophora sp. No. 2 rr, 9 rr, 10 rr, 11 rr, 12 rr, 14 rr.
Isthmia enervis No. 15 rr.
— nervosa Kütz. No. 9 rr, 10 rr.
Licmophora sp. No. 8 rr, 10 rr, 14 rr.
Nitzsch. Clost. W. Sm. No. 2 rr, 13 rr, 17 rr.
Paralia sulcata (Ehrh.) No. 2 rr, 3rr, 6 r, 10 rr, 12 r, 13 rr, 14 r, 15 r.
Pleurosigma sp. No. 1 rr, 7 rr, 13 rr, 17 rr, 16 rr, 17 rr, 20 rr.
Rhabdon. arcuat. (Lyngb.) No. 9 r, 11 rr.
Rhiz. faeroënsis Ostf. No. 15 r, 17 rr, 19 rr.
Bottom diatoms No. 1 rr.
Ceratium candelabrum (Ehbg.) Stein. (dead) No. 11 rr.
Cerat. macroc. (Ehbg.) Cl. (dead). No. 15 rr.
Dinophysis acuminata Cl. L. No. 19 rr.
— rotundata Cl. C. No. 19 rr.
Goniod. polyedr. (Pouch.) Jørgs. 19 rr (d).
Heteroc. triquet. (Ehbg.) Stein. No. 19 rr.
Peridinium asymmetricum (Mang.) Ostf. (= Diplopsalis lenticula) No. 11 rr, 16 rr, 17 rr, 19 rr, 21 rr
— breve Pauls. No. 18 rr.
— brevipes Pauls. No. 14 rr.
— conicoides Pauls. No. 6 rr, 7 rr, 17 rr, 18 rr, 19 rr.
— conicum Gran. No. 6 rr, 12 r, 13 rr. 15 rr, 16 rr, 17 r. 20 rr.
— curvipes Ostf. No. 5 rr, 17 rr, 18 rr. 19 rr, 20 rr, 21 rr.
— lenticula (Bgh.) No. 16 rr.
(= Dipls. lenticula var. minor)
— ovatum (Pouch.) Schütt. No. 8 rr, 16 rr, 18 rr.
— pallidum Ostf. No. 9 rr, 13 rr.
— pellucidum Gran. No. 18 rr, 19 rr.
— pentagonum Gran. No. 6 rr. 8 rr, 10 rr, 13 rr.
— pyriforme Pauls. No. 17 rr.
— roseum Pauls. No. 21 rr.
— subinerme Pauls. No. 4 rr.
— Thorianum Pauls. No. 18 rr, 19 rr, 20 rr.
— sp. No. 21 rr.
Protoceratium reticulatum (Clap. L.) Nitzsch. No. 16 rr.
Globig. bulloides d'Orb. No. 10 rr, 20 rr.
Disteph. specul. (Ehbg.) No. 1 rr, 12 rr, 19 rr.
Cyttarocylis denticulata (Ehbg.) No. 1 1 rr, 14 rr, 16 rr. 19 rr.
Cyttarocylis gigantea Brandt. No. 2 rr.
— norvegica (Dad.) Jørgs. No. 16 rr.
Tintinnopsis sp, No. 1 rr, 2 rr, 5 rr, 8 rr, 13 rr, 14 r, 16 r, 17 rr, 19 rr, 21 rr
Calan. finm. (Gun.) No. 9 rr, 10 rr, 20 rr.
Microsetella atlantica Brad & Rob. No. 11 rr, 16 rr.
Paracalanus parvus (Claus). No. 9 rr.
Pseudocalanus elongatus Boeck. No. 15 rr, 16 rr.
Temora longicornis (O. F. M.) No. 8 rr.
Eggs of Copepoda (?) No. 5 rr, 6 rr, 7 r, 8 rr, 9 r, 19 r, 11 rr.
Philomedes Liljeborgii G.O.Sars. No. 6 rr.
Larvae of Annelida. No. 9 rr, 11 rr, 15 rr.
Scales of butterflies. No. 12 rr.

ceras debile, Evadne Nordmanni and *Podon Leuckartii.* — Another point of difference is, that *Nitzschia seriata* in Section III occurs in such quantities (3—9 millions per sample) that it must be regarded as one of the dominant species, whereas in the two other sections, the figures for this do not exceed some few hundred thousand per sample. This agrees with the conditions found off Tveraa (Table I), where *Nitzschia,* as above mentioned, was extremely numerous in the last sample.

3. The separate sections all show that some species decrease in quantity from the base of the fjord out towards the mouth, while others increase in the same direction. And it is in the main the same species which thus increase and decrease in all three sections. To give a survey of these conditions, I have compiled from the figures in Tables III and IV the scheme shown in Table V, giving the ratio between number of cells (or individuals) of the most important species at St. 18 outside the fjord, and the

Fig. 5. Chart of stations in Trangisvaag fjord. After J. P. Jacobsen.

number up in the inner waters. There being in most cases several stations in this latter part, I have taken the average of all where this was so. Station 13 from Table IV is not included, as we fished there from 22—0 m. In cases where hauls were made from 30—0 m at Station 18 outside the fjord (owing to the inferior density of the plankton) I have halved the figures found, and as the plankton occurs in greater quantity near the surface than lower down, I hope to have thus obtained values somewhere near the true figures for hauls from 10—0 m.

In Table V, the species are so grouped that those which were more numerous in all sections up in the fjord than outside are placed at the top, the ones at the bottom being those in which the reverse was the case. Between these two extremes are noted the species which vary in this respect for the three sections.

Let us now consider these groups a little more closely.

A. Species decreasing towards the mouth of the fjord. These are, in other words,

organisms which appear in great quantities in the inner part of the fjord, but are more sparsely found, or lacking altogether, outside the mouth. These we can consider as having a centre of distribution in the inner fjord; being indigenous, or endogenetic (AURIVILLIUS) here. This does not, however, mean that they are only endogenetic here, as most of them belong to the neritic plankton which is found round about the Færoes. In the open sea, however, even at a slight distance from land, they do not attain anything like the quantity found up in the deep fjord, where the conditions (of nourishment) must be particulary suited to their needs. There are only two of the species which I regard as being locally restricted to the fjord, viz. *Evadne Nordmanni* and *Podon Leuckartii*. These species are found so rarely and so far apart in the open sea round the Færoes, that they may here be regarded as derived from the fjord populations. That *Evadne* has been found in quantities out in the open sea, whence it must have been washed out from the shore, we know from HENSEN.[1]

Among species endogenetic in the inner part of the fjord we must first of all note the above-mentioned group Table V,[2] i. e. those which in all three sections are seen to decrease from the inner waters out towards the mouth, and secondly some of the species in the next group, viz. *Skeletonema costatum, Philomedes Liljeborgii* and probably also *Centropages hamatus*. The figures for these species at stations in the inner fjord are more or less alike for all sections, which would seem to suggest that they have been evenly distributed in the water, and not brought in from without. Had they been so, their distribution would in all probability have been more irregular. That each of them was found in one case to be more numerous at the mouth probably only means that they had drifted out from the inner fjord, where they are normally to be found in greater number than in the open sea. — Further, we have in this group also of micro-plankton species not counted (according to Table II): *Chætoceras Diadema* and *simile, Fragilaria islandica, Nitzschia delicatissima, Thalassiothrix nitzschioides* and *Phaeocystis Pouchetii*. (Both *Coscinosira polychorda* and the two *Thalassiosira* species also belong to this group — according to Table II — so that there is hardly anything essentially incorrect in taking them together in the counts.)

As regards the counted species of this group (the endogenetic) we find in Table V a striking difference between Section I and the two other sections, the fractions in the firstnamed being far smaller (the denominators larger) than in the others. That is to say, on the 29th of May, (Section I) the endogenetic species were comparatively (and as a rule also absolutely) far more numerous in the inner fjord, and far less so outside the mouth than on the 6th and 16th June. Only *Temora* forms an exception from this; but the difference ($^1/_2$, $^1/_4$) is so slight, and the figures for this species in Table IV are so small, that it may be disregarded.

On the 6th and 16th June, however, the endogenetic species were present in comparatively (and as a rule also absolutely) greater quantities at the mouth of the fjord than on the 29th May, though most of them were, on the dates first mentioned, found in far smaller numbers than on the 29th May. On the 29th of May, then, the endogenetic species were proportionately most numerous in the inner fjord, but proportionately least so in at the mouth, while on the 6th and 16th of June, the reverse was the case.

B. Species increasing in quantity towards the mouth of the fjord. These species, which either occur only at the mouth of the fjord, or are more numerous there than farther in, appear accordingly to be allogenetic in the fjord, i. e. they are, when found there at all, only visitors brought in from without. To this group belong the four species named in Table V, viz. *Chætoceras boreale, Calanus finmarchicus, Sagitta* and the transparent Terebellide larvæ; also, probably, Ceriantharia larvæ, of which, however, so few were found that they cannot be taken into consideration. *Chætoceras teres* would seem, from Table II, to belong to this group.

[1] H. H. GRAN: Das Plankton des Norwegischen Meeres. Bergen 1902.

[2] Cirriped larvæ and decapod larvæ in Table IV, I have not here taken into consideration, as several species of these occur.

Table III. MICROPLANKTON FROM STATIONS FOR

Vertical hau

	Section I, May 29th							
Station No.	8	9	11	12	17	17	18	
Vertical haul, metres	10—0	10—0	10—0	10—0	10—0	25—13.5	10—0	2
Counted	1/10.000	1/2.000	1/2.000	1/2.000	1/800	1/800	1/800	
Volume of plankton sample in cm³	0·7	1·0	0·8	1·2	0·3	0·1	not measur	
Chaetoceras boreale	—	—	—	—	1.600	1.600	1.200	
— debile	104.400.000[1]	103.800.000[1]	126.600.000[1]	[3]	25.968.000[1]	8.572.000[1]	121.400	4
— decipiens	40.000	300.000	440.000	260.000	96.900	36.800	31.800	4
Leptocylindrus danicus	870.000	1.640.000	1.460.000	1.320.000	140.000	29.600	8.400	
Nitzschia seriata	380.000	200.000	320.000	220.000	102.400	14.000	23.400	
Skeletonema costatum	310.000	280.000	100.000	100.000	13.600	—	—	
Thalassiosina + Coscinosira	7.400.000	9.820.000	7.580.000	19.100.000	1.321.600	57.600	1.200	

[1] diluted 100 times before counting. [2] diluted 200 times before counting. [3] lost.

Here also we find that Section I differs from II and III, albeit not in the same way as in the case of the endogenetic species; in the present case, it was only on the 29th of May (Section I) that any of the allogenetic species were met with at all in the inner part of the fjord, and of these, only two were found, viz. *Calanus* and *Sagitta.*

With regard to *Chætoceras decipiens* and *Nitzschia seriata*, various points would seem to suggest that they are allogenetic in the fjord. In the first place, they have been found in plankton samples round about the Færoes in greater numbers than for instance *Chætoceras debile*, and furthermore, in the inner part of the fjord, they appear in greatly varying quantity at stations closely adjacent, which looks as if they had drifted in as "clouds". And again in Sections II and III, they are seen to be quite as numerous outside the fjord as inside, or possibly more. In Section I, they are far more numerous up in the fjord. Finally, about the middle of June, as will be seen below, the figures for both species in the waters round the Færoes, outside the Fjord, are seen to increase. Both are, however, it is true, found in considerable numbers up in the fjord, especially in Section III, *Nitzschia* in particular, the maximum for which at this time has been referred to above. In the case of this species, a glance at the figures for Section III (Table III) leads us to the conviction that the maximum must have come from without, penetrating up into the fjord. That the species should, however, thereafter be able to live and multiply there is of course possible, or even probable. The figures for Section I show that on the 29th May it was far more numerous up in the fjord than outside, and we might imagine that we had here living on, up in the fjord, the remains, so to speak, of an earlier *Nitzschia* maximum which had long vanished out in the open sea. *Nitzschia seriata* (and *Chætoceras decipiens*) may, then, perhaps after all be endogenetic.

The difference between Section I and the two other sections answers to the difference which we could imagine as produced by different current directions. With an ingoing surface current flowing up through the fjord, a number of species would be carried in from without, and the endogenetic species would be unable to slip out, but would be packed together at the base of the fjord. This corresponds to what we found in Section I, where the plankton was closely packed, and contained allogenetic species, while the endogenetic forms were very rare at the mouth of the fjord.

With an outgoing surface current, on the other hand, the endogenetic species would be carried out to the mouth, and allogenetic forms would be prevented from moving in, and the plankton in the inner part of the fjord would be diluted by bottom water with an inferior plankton content. This answers to the facts as shown for Sections II and III, where the plankton was thinner, and the allogenetic species were lacking at the base of the fjord, while the endogenetic were relatively numerous at the mouth.

GITUNINAL SECTIONS" OF TRANGISVAAG.
et, cells counted.

	Section II, June 6th			Section III. June 16th				
	11	17	18	8	11	17	17	18
-0	10—0	10—0	30—0	10—0	10—0	10—0	30—15	30—0
00	1/1.000	1/800	1/800	1/10.000	1/10.000	1/10.000	1/1.000	1/1.000
7	—	not measurable		0.8	0.8	0.5	0.2	0·6
—	—	1.600	4.000	—	—	40.000	1.000	4.000
2.000[2]	15.900.000[2]	8.320.000[1]	8.080.000[1]	33.230.000[1]	25.340.000[1]	20.120.000	5.781.000	6.620.000
3.400	20.000	186.600	655.200	340.000	1.130.000	1.350.000	403.000	1.232.000
0.000	211.000	172.000	64.000	240.000	550.000	280.000	15.000	57.000
3.400	25.000	216.800	244.000	4.180.000	4.690.000	9.620.000	3.516.000	22.880.000
2.400	3.000	3.200	4.800	40.000	190.000	30.000	9.000	—
2.800	1.234.000	133.600	74.400	6.860.000	2.980.000	4.810.000	222.000	1.128.000

Whether the currents at the time when the sections were taken actually were as here suggested, we cannot decide, *inter alia* because it took us the whole of a day — and sometimes part of the following — to work out a section, owing to the many different investigations made from each station.

The result of the foregoing observations and considerations we may sum up as follows:

1. The plankton of Trangisvaag Fjord consists in the main of the same species as those composing the plankton outside the fjord.

2. Most of the species occur in far greater numbers up in the fjord than outside; the fjord must thus offer especially favourable conditions — or possibly the greater density of the plankton may be merely due to the fact that the fjord water is only slowly renewed by mixing, while the mixing process, and thus also the dilution and removal of the plankton, would take place far more rapidly out in the open sea.

3. There are, however, a small number of species which are locally restricted to the fjord itself, and are only to a slight degree carried out into the open sea — and some few others, again, which are never, or only occasionally and in small quantities, carried into the fjord.

4. Save for the species referred to under 3, the fjord seems to obtain its plankton organisms from the open sea outside, by means of current transport.

5. The composition of the plankton during the three weeks or less embraced by the investigations remained almost unaltered in qualitative respects, but in point of quantity, considerable fluctuations were apparent, which appear to originate partly from alterations in the currents, thus the change in the total quantity of plankton, while the ratio between the separate component species remained almost the same — partly, again, evidently from the fact that certain species commence to appear in greater quantity. This last applies to *Nitzschia seriata* at the middle of June.

III. INVESTIGATIONS AS TO STOMACH CONTENTS OF FISH IN TRANGISVAAG FJORD.

As will be seen from Table IV, the macroplankton in Trangisvaag Fjord consisted chiefly of crustaceans, among which *Evadne Nordmanni*, *Podon Leuckartii* and *Acartia longiremis* were the most numerous; other copepods than the last named, however, and various Coelenterata, were also frequent.

In order to ascertain what might be the importance of the plankton fauna for the fishes there, I opened the stomachs of various fish and examined the contents. A list of the matter found is given below.

I. *COD.*

(Gadus Callarias) of I. Gr., 11—40 cm long.

1. Crabs, small fishes.
2. *Mysidae,* green mass.
3. *Crustaceae (Copepoda?)*
4. 1 Gammarine.
5. Remnants of *Calanus finmarchicus* and other *Copepoda.*
6. *Copepoda.*
7. *Copepoda.*
8. Empty.
9. —
10. *Mysidae, Calanus.*
11. *Mysidae, Crabs.*
12. *Mysidae, Terebellide-larvae, Decapod-larvae.*
13. Remnants of *Crustaceae.*
14. *Mysidae,* large lumps (of Crabs?).
15. Remnants of *Crustaceae.*
16. Many *Mysidae i. a. Gastrosaccus.*
17. *Mysidae.*
18. *Mysidae, Gammarinae.*
19. *Mysidae,* some *Calanus finmarchicus.*
20. *Mysidae,* 1 *Calanus finmarchicus,* 1 small snail.
21. *Mysidae.*
22. Remnants of fish and of *Laminaria.*
23. 1 Crab, many *Terebellide-larvae,* 1 large Annelide, *Polysiphonia.*
25. Remnants of *Crustaceae,* pieces of herring, maxillas of *Annelidae.*
26. *Gammarinae, Calanus finmarchicus.*
27. Young-fish.
28. Gammarine, small fishes.
29. Small fishes.
30. Empty.
31. *Gammarinae,* remnants of fish.
32. — —
33. Undistinguishable.
34. A great many *Gammarinae.*
35. — 1 cod.
36. 1 Annelide, remnants of *Crustaceae.*
37. 1 cod, many *Gammarinae.*
38. Remnants of fish.
39. 1 Myside, *Gammarinae.*
40. Undistinguishable.
41. 1 Annelide, *Gammarinae.*
42. A great many *Gammarinae.*
43. Many *Gammarinae,* remnants of fish.
44. Crabs, 1 Gammarine.
45. *Gammarinae,* remnants of fish.
46. Undistinguishable.
47. 1 Gammarine, 1 Myside.
48. 1 Young fish, many *Gammarinae.*
49. — —
50. *Gammarinae.*
51. 1 large Gammarine.
52. A great many *Gammarinae.*
53. Remnants of fish, *Gammarinae, Ceramium.*
54. Remnants of *Crustaceae.*
55. Remnants of fish, *Gammarinae, Mysidae.*
56. Undistinguishable.

II. *COAL-FISH (Gadus virens)*

of I-Gr. 14—33 cm long.

1. Remnants *of Crustaceae.*
2. 2 large *Annelidae,* many *Philomedes Liljeborgii,* green mass (of *Ulva?*)
3. Remnants of *Crustaceae.*
4. *Calanus finmarchicus.*
5. Many *Philomedes;* larvae of *Cirripedia; Podon,* young of *Ammodytes,* small snails, *Calanus finmarchicus.*
6. Many *Philomedes;* fish eggs, small snails.
7. *Philomedes, Temora,* fish-eggs, small snails, young *Mysidae; Centropages, setae of Annelidae.*
8. *Calanus finmarchicus,* small snails, larvae of *Cirripedia; Pseudocalanus elongatus.*
9. *Podon,* small snails; *Philomedes, Evadne, 1 Thysanoëssa,* larvae of *Cirripedia* and of Crabs.
10. Fish-eggs, *Calanus finmarchicus,* small snails.
11. A large Annelide; *Pseudocalanus,* fish-eggs.
12. 1 Gammarine, fish-eggs, remnants of *Crustaceae.*
13. *Calanus finmarchicus,* fish-eggs.
14. *Calanus finmarchicus, Philomedes,* fish-eggs.
15. *Calanus finmarchicus.*
16. A few large *Annelidae; Mysidae,* green mass.
17. Small crabs, *Annelidae.*
18. Remnants of *Annelidae,* green mass.
19. *Calanus finmarchicus, Annelidae.*
20. *Annelidae,* a Gammarine, green mass.
21. *Annelidae,* green mass.
22. — —

From the above list it will be seen that the cod and coalfish live both on plankton organisms and bottom forms, as well as on animals living in the weed beds. There is this difference, however, between the two, that the coalfish feeds to a greater extent than the cod on plankton, while gammarines appear to form the staple nourishment of the young cod.

IV. PLANKTON INVESTIGATIONS ON THE FÆROE BANK.

South-west of the Færoes, at a distance of some 50 miles, lies the so-called Færoe Bank, the minimal depth of which is abt. 100 m, and which has an extent of abt. 45 miles from NE—SW within the 200 m limit. The bank is surrounded on all sides by deeper water; the 600 m curve, which entirely encircles it, save perhaps towards the NE, lies at a distance of 10—50 miles from the 200 m line. Between the bank and the shallow water round the Færoes, again, there is also deep water; on one of the "Thor" expeditions, a depth of 250 metres was sounded here, but whether the lead happened to find a hole, or whether there really is a channel of this depth, is not known. At any rate, the isobaths on the accompanying chart (fig. 5) are not altogether correct as regards the channel between the Bank and the Færoes.

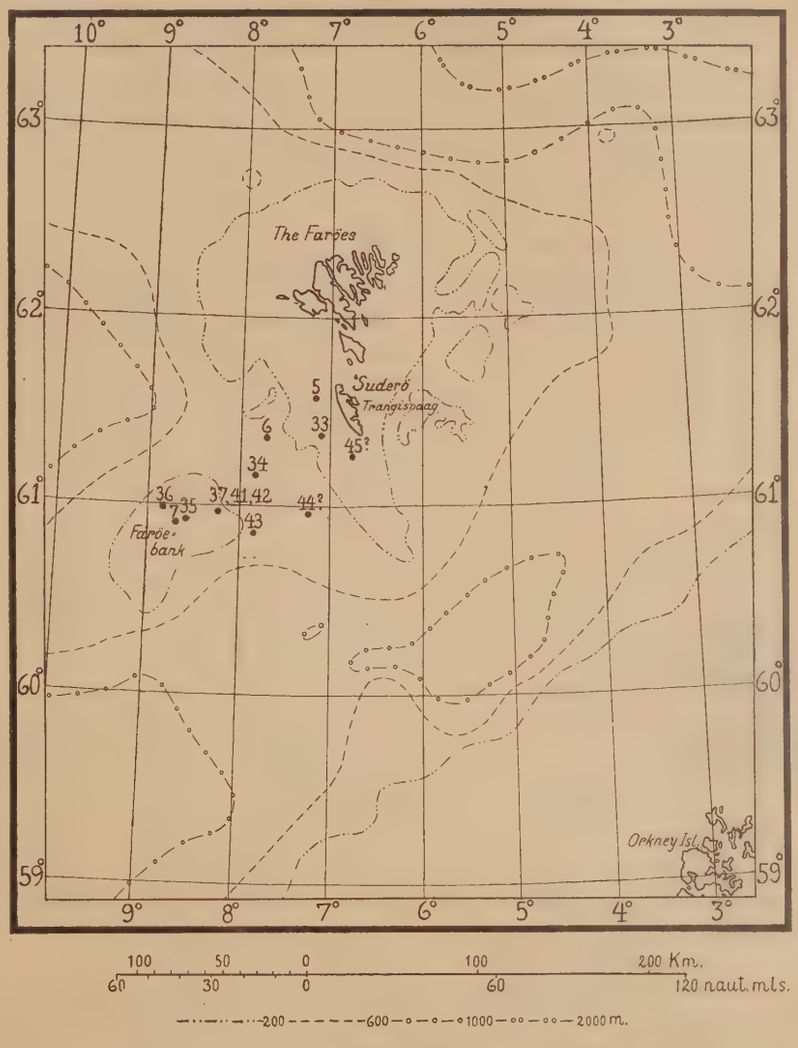

Fig. 6.

The Færoe Bank is in practical respects a highly interesting ground; an extensive cod fishery takes place here in the spring, both native and foreign fishermen participating. In the spring months, the fish spawn on the bank. Johs. Schmidt [1] has found pelagic eggs or young of cod (*Gadus callarias*) Coalfish (*G. virens*) and haddock (*G. æglefinus*) besides other fish. The species mentioned spawn only in shallow water, and their eggs and young are found in quantities round the Færoes, but in the channel between the bank and the Færoes themselves they have not been found.

According to the information available, the stock of fish on the bank is separate from and independent of that on the island grounds; only in a very few cases have marking experiments revealed any migration of fish from the bank to the Færoes or vice versa.[2]

[1] Johs. Schmidt: The distribution of the pelagic fry and the spawning regions of the gadoids in the North Atlantic from Iceland to Spain. (Conseil internat. pour l'explorat. de la mer, Rapports et Procès-Verbaux, X). Copenhague 1909.

[2] A. C. Strubberg: Marking experiments with cod at the Færoes (Medd. fra Kommiss. for Havundersøg., Ser. Fiskeri, Bd. V., No. 2) København 1916.

Table IV.

MACROPLANKTON FROM STATIONS FORMING 3 "LONGITUDINAL SECTIONS" OF TRANGISVAAG.

Vertical hauls with egg-net; counted 1/20 of each sample.

	Section I, May 29th									Section II, June 6th			Section III, June 16th		
Station No.	9	11	12	13	13	14	17[1])	17	18	11	17	18	8	14	18
Vertical hauls, metres	10—0	10—0	10—0	10—0	22—0	10—0	10—0	25—0	30—0	10—0	30—0	30—0	10—0	10—0	30—0
Copepoda.															
Acartia longiremis (Liljeb.)	2520	1140	3020	7960	4270	5540	1610	930	140	2470	38	570	2920	15080	1760
Calanus finmarchicus (Gunn.)	20	20	20	40	70	20	20	70	810	..	30	190	..	...	840
Centropagus hamatus (Liljeb.)	..	60	60	60	..	20	20	50	..	20	15	110	100	200	80
Oithona similis Claus.	..	..	..	..	..	..	..	..	..	..	..	40	..	...	240
Pseudocalanus elongatus Boeck.	100	40	60	180	120	..	..	20	50	300	37	200	100	120	160
Temora longicornis (O. F. Müll.)	40	..	40	140	200	60	..	40	50	130	20	60	40	40	80
Crustacea cetera.															
Evadne Nordmanni Lovén.	1300	3420	640	720	990	620	60	110	..	670	6	..	300	100	..
Philomedes Liljeborgii G. O. Sars	100	20	20	20	150	60	40	20	..	40	1	..	..	...	100
Podon Leuckartii G. O. Sars	5620	2900	4160	4600	5060	4940	3470	1640	10	1850	5	10	60	120	20
Gammarinae	..	..	..	..	..	..	..	..	..	2	..	..	..	...	20
Cirripedia larvae	480	620	220	680	1260	900	1150	260	45	60	26	1450	60	120	500
Dec. larvae	140	180	220	80	200	120	50	60	50	130	11	30	40	20	140
Zoea of crabs	..	..	..	..	..	..	..	..	..	160	6	10	..	120	120
Vermes.															
Sagitta	..	1	..	1	1	4	4	10	12	..	11	80	..	20	120
Nereis larvae	..	..	..	..	..	..	..	..	..	..	...	..	..	...	40
Terebellide-larvae	..	..	..	..	..	..	60	80	70	..	28	10	..	...	60
Cocleuterata.															
Obelia sp.	220	840	120	..	550	1	40	100	..	1390	..	20	2460	680	
Sarsia tubulosa (Sars)	32	20	5	3	..	..	1	..	7	12	..	20	20	1	60
Ceriantharia-larvae	..	..	..	..	..	..	..	1	20	..	..	10			
Mollusca.															
Larvae of snails	40	100	80	40	490	120	150	90	60	630	22	70	1180	180	60
Protochorrata.															
Oikopleura sp.	..	..	..	..	..	..	..	1							
Pirces.															
Fish-larvae	..	..	..	1	..	..	..	1							
Eggs of Motella	1	30	2	..	..	..	1	..	..	1					
— - Brosmius brosme	..	3	1	..	..	..	..	..	..	1					
— - Pleuronectes microcephalus	..	80	2	..	?4	2									
— - P. limanda or Pflesus	4	5	3	3	?5	4	1	2	..	2					

[1] part of this sample was lost.

In 1904,[1] it was found that the water above the Færoe Bank was both somewhat colder and somewhat fresher than that round the Bank, and the same feature was noted by JOHS. SCHMIDT on the Rockall Bank (l. c.) In 1904 and later in 1910 I found that the plankton living in the sea above the Færoe Bank

[1] J. E. NIELSEN: Contribution to the hydrography of the eastern part of the Atlantic Ocean. (Medd. fra Kommiss. for Havunders., Ser. Hydrografi, Bd. I, No. 9) København 1907. OVE PAULSEN: Plankton investigations in the waters round Iceland and in the North Atlantic in 1904. (Medd. fra Kommiss. for Havunders., Ser. Plankton, Bd. I, No. 8) København 1909. The same: The Plankton on a submarine Bank (Biol. Arbejder tilegn. Eug. Warming). 1911.

was more numerous and more neritic than that from the surrounding water. That a rich and neritic plankton should be met with far from any coast seemed strange, but the fact was ascribed to the introduction of water from lower depths by means of vertical currents; in other words, an intensive mixture of the water layers occasioned by the bank. This view has also been advanced by hydrographers as an explanation of the hydrographical conditions of the bank water, with regard to which, reference may be made to M. KNUDSEN and J. P. JACOBSEN.[1]

Investigations as to the plankton of the Færoe Bank have also been made on two subsequent occasions. In the first instance, I persuaded Capt. G. HANSEN, who went to the Færoes in May/June 1912 on fishery business, to collect a series of plankton samples with a small plankton net of fine gauze (No. 20) on the bank and outside. Ten samples were taken from the bank, two from the channel, and four from the shallow water round the Færoes. They were taken by towing the net horizontally through the water in the wake of a fishing cutter under sail, for five minutes at a time, but as the rate of sailing naturally varied, they can hardly be taken as quantitative samples. As regards the composition of the plankton, they show, that:

1. In the Færoe waters themselves, the plankton was quantitatively very rich, the dominant species being *Chætoceras decipiens, debile, constrictum, contortum.* Constant and frequently occurring components were also *Rhizosolenia Shrubsolei, Thalassiosira Nordenskiöldii.* Various other species occurred sparsely or rarely.

2. The plankton of the Færoe Bank was considerably richer in species; as regards quantity, it varied greatly, some samples being evidently as large as those from the Færoes, while others were rather small. Dominant species here were *Chætoceras laciniosum, debile, decipiens, atlanticum,* and in certain samples *Nitzschia delicatissima,* while the following were of constant or frequent occurrence: *Chætoceras boreale, densum, Nitzschia seriata, Rhizolenia styliformis* and *alata; (Rh. Shrubsolei* also was found in most of the samples, but seldom frequent), *Thalassiothrix longissima, Dinophysis acuminata* and *acuta, Gonyaulax spinifera, Peridinium pellucidum, Phaeocystis Pouchetii, Cyttarocylis denticulata.* To these may be added *Thalassiosira bioculata* and *Nordenskiöldii, Coscinodiscus excentricus, subbuliens* and *radiatus,* which occurred in a number of samples, and various Peridinea *(Ceratium fusus, intermedium, lineatum, Peridinium depressum (parallelum), pallidum,* etc. as to which the same may be said.

This plankton appears to be a mixture of neritic and oceanic elements, and thus resembles that found in 1910. We are accustomed, for instance, to regard *Chætoceras debile* and *laciniosum* as coastal forms, *Chætoceras densum, Thalassiothrix* and the Peridineans as oceanic species. With regard to

Table V. Ratio between number of cells or animals pr. sample outside Trangisvaag fjord (Stat. 18) and at the inner stations in the fjord (average).

Name of species	Section I	Section II	Section III	
Chaetoceras debile	1/900	1/4	1/8	In all sections more numerous *in* the fjord.
Leptocylindrus danicus	1/150	1/4	1/14	
Thalassiosira + Coscinosira	1/9000	1/32	1/8	
Acartia longiremis	1/50	1/8	1/3	
Pseudocalanus elongatus	1/8	1/2	1/1	
Temora longicornis	1/2	1/4	1/1	
Evadne Nordmanni	0/1	0/1	0/1	
Podon Leuckartii	1/900	1/370	1/6	
Obelia sp.	0/1	1/140	0/1	
Sarsia tubulosa	1/2	1/1	0/1	
Chaetoceras decipiens	1/9	23/1	1/1	Different.
Nitzschia seriata	1/12	1/1	3/1	
Skeletonema costatum	0/1	1/1	0/1	
Centropages hamatus	0/1	3/1	1/2	
Philomedes Liljeborgii	0/1	0/1	1/0	
Chaetoceras boreale	1/0	1/0	1/0	In all sections more numerous *outside* the fjord.
Calanus finmarchicus	8/1	1/0	1/0	
Sagitta sp.	3/1	1/0	1/0	
Terebellide-larvae	1/0	1/0	1/0	

[1] MARTIN KNUDSEN: Danish hydrographical Investigations at the Færoe Islands in the Spring af 1910 (Medd. fra Kommiss. for Havunders., Ser. Hydrografi, Bd. II, No. 1) København 1911. J. P. JACOBSEN: Hydrographical Investigations in Færoe waters (ibid. No. 4) København 1915

Table VI. PLANKTON FROM THE SHALLOW WATER W. OF THE FAEROES,

Number of cells pr. litre

	Shallow water W. of the Faeroes											The channel								
No.	4	5	6	8	10	13	50	49	48	47	73	14	15	17	19	21	54	53	52	51
Station	5	—	—	—	—	—	33	—	—	—	45	6	—	—	—	—	34	—	—	—
Date	24·V	—	—	—	—	—	9·VI	—	—	—	15·VI	25·V					9·VI	—	—	—
Latitude N.	61°35	—	—	—	—	—	61·22	—	—	—	W. of Suderø	61·21					61·10	—	—	—
Longitude W.	7°.11	—	—	—	—	—	7·03	—	—	—		7·42					7·48	—	—	—
Depth of water (m)	119	—	—	—	—	—	140	—	—	—	105	>260					>250	—	—	—
Depth of haul (m)	0	10	20	40	60	100	0	20	50	75	0	0	10	30	50	70	0	20	50	75
Salinity (‰)	35·19	35·19	35·21	35·21	35·18	35·23	35·23	35·17	35·17	35·14	35·19	35·30	35·30	35·30	35·30	35·28	35·26	35·25	35·25	35·26
Temperature (C°)	7·45	7·40	7·28	7·22	7·24	7·23	7·90	7·70	7·68	7·68	8·13	8·44	8·32	8·16	7·93	7·62	9·73	9·45	9·02	8·66
Ccm axamined	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	10	50	50	50
Total number of cells pr. litre	11880	3780	4320	5240	5590	4530	15480	12220	12240	14480	131040	10150	5220	4000	3490	1210	24900	19500	1260	600
Diatomaceae.																				
Cerataulina Bergonii Perag.	100	...	...	...	...	20	...	...	...	...	60									
Chaetoceras atlanticum Clev.	...	...	...	...	...	...	...	...	...	...	60	...	...	60	...	...	...	...	...	...
— boreale Clev.	1900[4]	80[4]	100[4]	20[4]	60[4]	...	20[4]	20[4]	...	...	17800[4]	...	...	80[4]	...	...	3350	4480	260	80[4]
— constrictum Gran.	440	...	40	...	...	...	40													
— contortum Schütt.	300	60	380	180	80	...	...	...	...	...	4140									
— convolutum Castr.	...	...	...	...	...	...	...	...	...	...	4420	...	...	...	...	...	1250	1160	120	...
— curvisetum Clev.	360	...	260																	
— debile Clev.	140	...	...	80	600	20	320	540	440	1160	2500	...	...	...	...	...	5650	2100	180	20
— decipiens Clev.	100	80	40	180	200	80	...	1140	460	700	2900	2400[1]	2820[2]	1980	2360	360	350	160	60	20
— Diadema (Ehbg.) Gran.	100	240	20	...	100	160	640	...	...	100	...	...	...	...	20					
— laciniosum Schütt.	40	60	200	...	60	100	...	...	80	40										
— simile Clev.	220	120	...	60	120	60														
— teres Clev.	40	20	...	...	...	...	720	...	20	60	...	80	100	440	260	60	...	...	...	...
Corethron criophilum Castr.	...	...	...	...	...	...	60	...	40	...	...	...	...	...	...	...	100	...	...	...
Coscinodiscus concinnus W. Sm.	...	...	...	...	...	...	...	...	...	...	20	...	...	...	...	...	...	...	...	...
— excentricus A. Schm.	20	...	...	...	...	...	...	...	...	...	...	...	...	...	...	40	...	...	...	...
— marginatus Ehrh.	...	...	...	...	...	...	40	40	...	...	...	...	20	...	40	...	...	...	...	...
— subbuliens Jørgs.	...	...	...	20	...	40	...	...	...	...	20	...	...	...	...	...	...	...	...	...
— sp.	...	20	...	...	40	...	...	...	20	...	...	20	...	...	...	...	...	...	...	40
Fragilaria islandica Grun.	380	520	160	860	520	440	...	...	...	...	...	40	...	...	40					
Leptocylindrus danicus Clev.	1320	140	100	940	400	360	360	140	340	920	720	20								
Licmophora sp.	20	100	...	...	20	20	20													
Nitzschia Closterium W. Sm.	40	80	20	20	60	60	...	...	40	20	200	...	20	20	20	...	...	...	...	...
— delicatissima Clev.	80	...	...	...	...	...	120	...	...	60	...	...	20	...	20	...	...	...	...	...
— seriata Clev.	1140	40	80	100	...	40	8320	5500	5800	5740	76800	...	...	20	...	...	...	...	...	...
Paralia sulcata (Ehrh.)	80	180	280	140	520	1180	680	320	...	...	160	...	...	...	...	60	...	...	...	...
Rhizolenia alata Btw.	20	...	10	...	...	10	...	...	160											
— faeroënsis Ostf.	...	...	20	...	...	...	...	...	100	100	380	...	...	...	...	...	...	...	...	...
— semispina Hens.	2020	40	490	100	160	50	...	...	...	...	...	20	20	...	10	10	...	...	...	...
— styliformis Btw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Skeletonema costatum (Grev.)	800	320	280	580	1000	240	560	340	200	1180	2420	...	...	...	...	...	...	...	...	...
Thalassiosira bioculata (Grun.)	...	...	...	...	40	40	...	...	...	...	200									
— gravida Clev.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Coscinosira polychorda Gran. / Thalassiosira gravida Clev. / — Nordenskiöldii Clev.	460	720	820	960	800	840	2470	3040	3600	3060	17200	100	20	...	40	40	200	60	...	20
— subtilis	...	60	...	20	10	120														
Thalassiothrix nitzschioides Grun.	400	180	420	...	280	300	160	...	140	...	100	...	...	40	80	...	...	...	...	...
Bottom diatoms	260	200	360	520	240	140	440	400	240	160	120	...	...	20	...	40	100	60	80	...
Silicoflagellatae.																				
Distephanus speculum (Ehbg.)	20	20	...	60	40	60	120	140	...	300	140	80	40	40	20	20	2150	520	60	20

[1] 200 with auxospores. [2] 80 with auxospores. [3] partly with spores. [4] incl. *Ch. convolutum*.

OM THE FAEROE BANK AND FROM THE CHANNEL BETWEEN THESE TWO.
's method.

				The Faeroe Bank																						
	70	69	72	24	25	26	27	28	29	31	32	33	58	57	56	55	60	59	61	62	64	63	68	67	66	65
	—	—	44	7	—	—	—	—	—	—	—	—	35	—	—	—	36	—	37	—	41	—	42	—	—	—
71	—	—	15 VI	25·V	—	—	—	—	—	—	—	—	10·VI	—	—	—	11·VI	—	12·VI	—	13·VI	—	14·VI	—	—	—
51	—	—	W. of Suderø	60·55	—	—	—	—	—	—	—	—	60·56	—	—	—	60·59		60·59	—	60·59	—	60·59	—	—	—
50	—	—		8·44	—	—	—	—	—	—	—	—	8·39	—	—	—	8·47		8·20	—	8·20	—	?8·20	—	—	—
90			500?	107	—	—	—	—	—	—	—	—	140	—	—	—	115		110	—	112	—	130	—	—	—
	20	50	0	0	10	20	30	40	50	70	80	100	0	20	50	75	0	50	0	50	0	50	0	20	50	75
30	35·28	35·30	35·30	35·28	35·28	35·28	35·28	35·28	35·26	35·28	35·26	35·25	35·23	35·23	35·26	35·26	35·26	35·23	35·26	35·26	—	35·28	35·26	35·25	35·26	35·25
70	9·54	9·30	9·7	8·54	8·52	8·48	8·32	8·32	8·28	8·26	8·26	8·26	9·28	9·20	8·52	8·46	9·05	8·65	9·10	8·79	9·20	8·82	9·20	8·85	8·66	8·64
	50	50	50	10	10	10	10	10	10	10	10	10	10	10	50	50	50	50	50	50	50	50	50	50	50	50
0	14420	6290	14210	20400	15400	15000	34400	32600	29300	26700	37800	36100	41400	37500	13450	10120	17140	10970	26340	21480	21280	12650	49440	23980	25020	12720
	...	...	...	...	...	...	...	...	...	...	...	...	700	300	80	80	110	140	80	80	60	60	200	40	120	
	560	240	100	2000[4]	500[4]	1500[4]	2300[4]	2200[4]	2100[4]	2100[4]	3000[4]	2700[4]	14900	14800	5440	4440	7480	3830	11960	10340	11600	6800	24040	10360	13660	5460
0	120	40	...	...	...	...	...	...	...	...	...	...	6700	5600	2040	1400	2190	1640	3320	2880	2500	1360	9700	4280	5780	2140
	540	20	140	12300	10300	10500	29700	27200	24100	20800	33300[3]	30400	10000	8800	4640	3100	3910	3900	6360	5920	3220	2880	8920	5420	3920	4080
	380	40	40	1300	700	100	400	1400	1000	1700	900	600	2200	3600	300	380	1120	560	880	1480	820	660	1820	560	560	260
	...	...	...	...	300	...	300	...	...	100	...	...	200	...	...	...	20	...	...	...	20	...	...	40		
	20	...	60																							
	...	...	...	...	...	100	...	...	...	...	...	100	...	...	100	60	...	...	40	...	40	60	60	...	40	40
	...	...	20	...	...	...	...	...	...	100	...	100	...	...	20	...	...	40	60	20	20	...	...	...	40	60
	...	...	...	200	200	100	100	100	100	300	100	200	...	...	100	80	30	60	60	20	...	...	60	60	...	100
	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	40	...	40	20				
	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	20	...	...	40	20	40	...	...	20	
	...	...	...	...	...	...	100	...	...	...	...	...	...	...	...	...	...	...	20							
	...	60	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	100							
0	9040																									
	...	...	...	...	...	...	...	...	...	...	...	...	...	...	180											
	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	200									
	...	...	10																							
	...	10	...	...	...	...	...	...	...	...	...	...	...	...	10	...	10	...	...	20	...	10	140			
	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	50	...	60							
0	2700	5240	12040																							
0	...	...	100	...	...	...	400	...	100	...	...	...	...	100	...	...	20	...	40	...	20	20	40	140		
	...	...	...	300	200	200	300	500	800	200	...	500	...	...	20	20	20	60	20	60	20	80	100	80	120	120
0	...	20	40	100	100	100	500	800	300	700	500	400	100	100	60	40	30	140	120	140	40	100	160	180	80	20
0	60	60	220	...	...	...	...	...	100	...	...	100	200	400	80	100	100	80	200	40	200	80	320	400	60	40

Table VI. PLANKTON FROM THE SHALLOW WATER W. OF THE FAEROES

Number of cells pr. litre

	Shallow water W. of the Faeroes											The channel								
No.	4	5	6	8	10	13	50	49	48	47	73	14	15	17	19	21	54	53	52	51
Station No.	5	—	—	—	—	—	33	—	—	—	45	6	—	—	—	—	34	—	—	—
Date	24·V	—	—	—	—	—	9·V	—	—	—	15·VI	25·VI					9·VI	—	—	—
Latitude N.	61°35	—	—	—	—	—	61·22	—	—	—	W. of Suderø	61·21					61·10	—	—	—
Longitude W.	7°. 11	—	—	—	—	—	7·03	—	—	—		7·42					7·48	—	—	—
Depth of water (m)	119	—	—	—	—	—	140	—	—	—	105	>260					>250	—	—	—
Depth of haul (m)	0	10	20	40	60	100	0	20	50	75	0	0	10	30	50	70	0	20	50	75
Salinity (‰)	35·19	35·19	35·21	35·21	35·18	35·23	35·23	35·17	35·17	35·14	15·19	35·30	35·30	35·30	35·30	35·28	35·26	35·25	35·25	35·2
Temperature (C°)	7·45	7·40	7·28	7·22	7·24	7·23	7·90	7·70	7·68	7·68	8·13	8·44	8·22	8·16	8·16	7·62	9·73	9·45	9·02	8·6
Ccm examined	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	10	50	50	50
Total number of cells pr. litre	11880	3780	4320	5240	5590	4530	15480	12220	12240	14480	132040	10150	5220	4000	3490	1210	24900	19500	1260	600
Peridiniaceae.																				
Ceratium lineatum (Ehbg.) Clev.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Dinophysis acuminata Clap. Lachm.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
— acuta Ehbg.	...	...	...	...	...	...	...	..	...	...	...	...	...	...	...	...	...	...	...	...
— rotundata Clap. Lachm.	...	...	20	...	...	...	...	20	20	...	...	...	...	...	...	...	...	...	...	...
Gonyaulax Levanderi (Lemm.)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	80	...	...
— sp.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Gymnodinium sp.	20	...	40	...	...	...	40	...	80	40	40	20	...	...	...	60	850	2340	20	20
Heterocapsa triquetra (Ehbg). Stein.	...	...	...	...	...	...	...	20	...	...	80									
Peridinium depressum Bail.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
— faeroënse Pauls.	...	...	...	...	20															
— minusculum Pavill.	80	40	...	...	...	...	...	...	...	20	...	...	...	...	...	...	...	20	...	20
— ovatum (Pouch.) Schütt.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	20
— pallidum Ostf.	...	...	20	...	...	...	...	...	...	...	20	...	...	...	...	...	...	...	...	...
— pellucidum Gran.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
— sp.	100	10	40	40	40	...	40	120	120	60	20	80	20	40	40	20	100	40	20	80
Cystae of Peridiniaceae	40	...	...	...	...	...	80	80	40	...	...	60	...	120	60	...	900	1960	80	20
Protozoa.																				
Codonella sp.	...	...	...	...	...	...	...	...	...	..	20	...	...	...	...	...	...	...	...	...
Cyttarocylis denticulata (Ehbg.)	...	20	...	..	...	20	...	...	...	...	20	40	20	...	...	...	100	500	40	20
— norvegica (Dad.) Jørgs.	100	20	20	20	20	20	20	20	60	60	20	40	...	20	60	40	850	200	20	...
Tintinnopsis beroidea aff.	40	20	...	40	100	20	20	...	...	...	...	20	..	...	...	60				
Laboea conica Lohm.	40	...	...	...	...	...	60	140	...	100	20	...	...	...	...	...	1250	60	...	...
— emergens Leeg.	...	...	...	...	...	...	...	...	40	...	...	350	200	40	40	40	200	...	...	...
— strobila Lohm.	20	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
— sp.	720	...	80	...	...	...	...	80	20	20	40	5820	1360	380	40	60	2950	1020	60	...
Woodania conicoides Leeg.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pachysphaera pelagica Ostf.	...	100	...	...	...	20	...	...	...	...	...	40								
Halteria sp.	140	...	...	...	...	...	20	20	40	60	...	60	80	220	20	...	150	180	20	80
Other Ciliata	...	...	...	...	...	...	40	100	80	100	20	...	180	...	100	100	500	480	100	80
Vampyrella Chaetoceratis (Pauls.) Ostf.	...	...	...	...	...	...	...	...	...	...	40	...	...	...	...	...	150	220	...	...
Fusopsis?	...	...	...	...	...	...	...	...	...	20	...	...	...	...	...	...	...	...	...	...
Globular cells with corrona	200	20	...	...	...	...	20	...	...	...	60	380	200	360	100	200	250	20	...	20
Naked cells with chromatophores	140	180	...	260	60	60	20	...	60	400	...	480	80	120	120	...	3500	3840	140	...
Meringosphaera sp.?	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Metazoa.																				
Nauplius	20	...	...	...	...	...	...	...	...	...	120	...	...	20						
Scales of butterflies	...	...	...	...	...	...	...	20	20	40	...	...	100	...	20	...	...	...	...	...
Excrements?	100	40	80	200	...	40	300	500	460	500	40	60	60	...	...	...	...	...	...	...

Also observed: Achnanthes sp. No. 72 : 40, No. 68 : 220; Actinoptychus undulatus No. 8 . 2; Chaetoceras criophilum No. 73 : 260; Ch. didymum C. intermedium No. 60 : 20; C. longipes No. 4 : 60; C. tripos atlanticum No. 73 : 20; Exuviella perforata Gran. No. 71 : 20; Gonyaulaux spinifera No. 61 : 20; Pterosperma dictyon No: 8 : 20; Hexasterias problematica No. 50 : 20.

OM THE FAEROE BANK AND FROM THE CHANNEL BETWEEN THESE TWO.

's method.

				The Faeroe Bank																						
	70	69	72	24	25	26	27	28	29	31	32	33	58	57	56	55	60	59	61	62	64	63	68	67	66	65
	—	—	44	7	—	—	—	—	—	—	—	—	35	—	—	—	37	—	37	—	41	—	42	—	—	—
I	—	—	15·VI	25·V	—	—	—	—	—	—	—	—	10·VI	—	—	—	11·VI	—	12·VI	—	13·VI	—	14·VI	—	—	—
1	—	—	W. of Suderø	60·55	—	—	—	—	—	—	—	—	60·56	—	—	—	60·59		60·59	—	60·59	—	60·59	—	—	—
0	—	—		8·44	—	—	—	—	—	—	—	—	8·39	—	—	—	8·47		8·20	—	8·20	—	?8·20	—	—	—
0			500?	107	—	—	—	—	—	—	—	—	140	—	—	—	115		110	—	112	—	130	—	—	—
	20	50	0	0	10	20	30	40	50	70	80	100	0	20	50	75	0	50	0	50	0	50	0	20	50	75
0	35·28	35·30	35·30	35·28	35·28	35·28	35·28	35·28	35·26	35·28	35·26	35·25	35·23	35·23	35·26	35·26	35·26	35·23	35·26	35·26	—	35·28	35·26	35·25	35·26	35·25
0	9·54	9·30	9·7	854	8·52	8·48	8·32	8·32	8·28	8·26	8·26	8·26	9·28	9·20	8·52	8·46	9·05	8·65	9·10	8·79	9·20	8·82	9·20	8·85	8·66	8·64
	50	50	50	10	10	10	10	10	10	10	10	10	10	10	50	50	50	50	50	50	50	50	50	50	50	50
)	14424	6290	14210	20400	15400	15000	34400	32600	29300	26700	37800	36100	41400	37500	13450	10120	17140	16970	26340	21480	21280	12650	49440	23980	25020	12720
	...	...	...	...	...	...	...	...	...	...	...	...	...	100	...	...	20	...	100							
	...	...	...	...	...	...	...	...	...	...	...	...	...	...	20	...	...	...	...	...	20					
	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	100							
	...	...	...	...	...	...	...	..	...	...	...	...	...	...	...	...	...	...	...	...	20					
	...	40	...	...	...	...	...	...	...	...	...	...	400	100												
	...	...	20																							
	20	...	200	...	...	...	...	...	...	...	...	...	200	...	20	...	...	...	80	...	240	...	100	60	...	20
	...	...	...	...	...	...	...	...	...	...	..	...	...	...	...	...	...	...	...	...	...	20	20			
	...	20	20	...	...	...	...	...	...	...	...	100														
	...	...	...	...	...	...	...	...	...	...	...	...	100	...	...	...	20									
	...	...	...	...	...	...	...	...	100																	
	...	...	...	...	...	...	...	...	...	...	...	...	100	...	...	...	20									
	40	60	80	100	100	...	...	100	100	...	...	...	500	300	...	...	20	...	60	20	40	...	60	20		
	260	80	80	200	...	100	...	100	200	200	...	400	600	400	40	60	40	40	280	80	140	...	140	140	...	40
	...	...	...	...	...	...	...	...	...	...	...	...	200													
	60	80	60	...	...	...	...	...	200	...	...	...	200	100	40	...	70	...	100	80	300	40	200	80	20	40
	20	...	...	...	...	...	...	...	...	...	...	100	300	200	20	...	120	100	180	20	260	60	460	320	60	60
	100	40	20	300	100	...	...	...	...	...	...	...	200	...	...	...	490	...	520	...	20	...	560			
	...	40	...	...	...	100	...	...	...	...	...	...	...	...	...	...	...	...	60	...	40	...	40	300		
	...	...	...	...	100	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	20					
	360	120	220	2400	...	...	...	100	...	...	...	100	100	...	...	...	100	...	100	...	120	...	580	40	...	40
	...	...	...	...	2500	2500																				
	20	...	20	100	...	...	...	...	100	200	...	...	100	...	...	...	30	20	100	...	80	...	...	120	40	
	...	20	200	700	100	100	200	...	...	...	...	...	...	...	...	...	160	...	240	...	260	...	480	220	20	100
	40	20	40	...	...	...	...	...	...	...	...	...	2200	1900	100	200	680	300	820	220	720	300	760	840	420	180
	...	...	...	...	200	...	...	...	...	200	...	200														
	80	...	20	400	...	100	100	...	...	100	...	100	300	...	...	...	60	20	120	...	280	...	80	180	...	20
	...	40	60	...	...	...	...	...	...	...	...	...	900	700	140	240	...	40	100	...	60	60	180	100	40	
	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	20	60					
	...	...	...	...	...	100	100	...	...	200	...	...	...	...	...	...	...	...	20	...	...	...	...	...	...	20
	...	...	20	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	20			

4 : 160; Rhizosolenia setigera No. 50 : 10, No. 51 : 20; Thalassiothrix longissima No. 13 : 10; Amphidinium sp. No. 50 : 20; Ceratium fusus No. 5 : 10; dinium divergens No. 4 : 20; Podolampas palmipes No. 15 : 20; Prorocentrum micans No. 15 : 20; P. scutellum No. 6 : 20; Tintinnus subulatus No. 66 : 20;

species, again, we find about the same as in 1910, one of the principal points of difference being the fact that the many *Coscinodisci* then found are here lacking.

3. Of the two samples from the channel, one shows the same plankton as on the bank, also rich in quantity, while the other consists of an almost pure oceanic peridinean plankton (*Ceratium furca, fusus, intermedium, Peridinium depressum, ovatum, pallidum, pellucidum*). The quantity was very small.

The second investigation of the plankton of the Færoe Bank was made by my self during the cruise of the "Margrethe" in 1913, when I collected a series of plankton samples according to Gran's method, both on the bank and during the voyage thither from the Færoes and back. These samples I examined at home on my return. The stations are marked on the chart fig. 5, and are indicated by the same numbers in Table VI, where the figures obtained from the counts are shown. From this table, it appears, that:

1. At the end of May and beginning of June, the plankton about the Færoes was neritic and fairly rich in species, but the figures are not particularly high, the most frequently occurring species being *Nitzschia seriata* and *Thalassiosira;* of constant species there are also *Chætoceras debile, decipiens, Leptocylindrus, Skeletonema* and *Thalassiothrix nitzschioides* etc. At the middle of May (St. 45) a marked and somewhat sudden increase in quantity is apparent, the figures for *Chætoceras boreale* and *Nitzschia seriata* especially rising considerably. In the case of the last-named species, the rise at this time has already been noted, see for instance Table III.

At two of the stations (St. 5 and 33) a number of deep water samples were taken; these show that the plankton down to 100 m in the one case, and 75 in the other, is not subject to great fluctuations of quantity or composition. The reason of this is probably that the Færoes, situated as they are in the midst of a disturbed region of sea with strong currents, effect a stirring up of the water, whereby the layers are mixed together. The same is pointed out by Gran [1] p. 120, who gives details of the hydrographical conditions and plankton from a Scottish station at the Færoes (not "Færö-Banken" as he calls it) where both plankton and salinity were alike from surface to bottom. The fluctuations in salinity also at stations 5 and 33 were only slight.

2. The plankton of the Færoe bank, which was investigated at 6 stations, comprising two visits, one at the end of May (St. 7) and one in the first half of June (St. 35—42) both interrupted by bad weather, consists of the following dominant species: *Chætoceras debile, decipiens, boreale, convolutum,* while *Chætoceras atlanticum, Coscinodiscus marginatus* and *Thalassiothrix nitzschioides* were, albeit few in number, nevertheless constantly present. Peridineans were sporadic, as also protozoans, and only the parasite *Vampyrella Chætoceratis,* living on *Chætoceras,* was probably constantly present, but was overlooked at the first station. *Cyttarocylis denticulata* and *norvegica* were found in most samples.

The plankton of the Færoe Bank in 1913 cannot be called poor in species, because there were not a few species which were only found in some of the samples, but the plankton is nevertheless poor in constantly occurring species of so frequent occurence as to be found in all samples. In this respect, the plankton of the bank differs from that of the Færoes proper. A comparison of the columns in Table VI will show this at a glance. Of the Færoe species, several are lacking on the bank, as for instance *Nitzschia seriata, Leptocylindrus; Thalassiosira* has become rare, while on the other hand, the *Coscinodiscus* species are more abundant on the bank than at the Færoes, and the same applies to *Chætoceras debile* in May.

Alltogether, the difference between the two planktou communities is not very great. The dominant species of the bank were also dominant, or at any rate of constant occurrence, at the Færoes, but some of the less frequent Færoe species were lacking on the Bank, where they were replaced by others. We

[1] H. H. Gran: The plankton production of the North European waters in the Spring of 1912. (Conseil permanent, Bull. planktonique 1912) Copenhague 1915.

can then characterise the plankton of the Færoe Bank as neritic, like that of the Færoes, but with a certain admixture of oceanic elements (*Chætoceras atlanticum*, *Coscinodiscus*) and this is the same result as I had previously arrived at for the plankton of the bank.

The list of species was about the same for May and June, and the total number of cells per litre was also very nearly the same in both cases.

As regards the density of the plankton, which chiefly depends upon the quantity of *Chætoceras debile*, at various depths, this was for all June stations greatest at the surface, as far as could be judged from the observations, while the maximum for May lay at about 80 m. In all cases, the salinity was almost unchanged, about 35·26 ‰ at all depths, while the temperature decreased with increasing depth.

3. The plankton in the channel between the Færoes and the bank differed at different times. In May (St. 6) it was dominated by *Chætoceras decipiens* alone, while also *Ch. teres* was constantly present, and *Laboea* species were numerous. This plankton of course, is neither the neritic plankton of the adjacent St. 5 nor that of the bank, but is possibly imported from the north, as the currents here flow mainly from that direction. In June we found at St. 34 (9 June) the plankton of the bank almost unaltered, whereas St. 43 and 44 (14 and 15 June) exhibited a very considerable admixture of a dwarf form of *Thalassiosira gravida*, *Chætoceras* species having decreased greatly in quantity. Where this last plankton can have come from, I am unable to say. Unfortunately, owing to very bad weather, we were not able to extend the investigations on the Færoe Bank beyond this, nor can anything be said as to what plankton was to be found south or west of the bank.

As will be seen from the foregoing, the water above the Færoe Bank contains a partly neritic plankton, which in certain respects resembles that of the Færoes themselves, but also contains oceanic elements. It appears to be surrounded by oceanic plankton communities in the adjacent waters. This side of the question, however, as also the extent of the bank plankton, has yet to be fully investigated, and I will conclude by expressing a hope that an opportunity may be found of prosecuting further researches, from a vessel well-equipped for the purpose — which the "Margrethe" by no means was — as to the bank plankton and its relation to that of the deep water surrounding.

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